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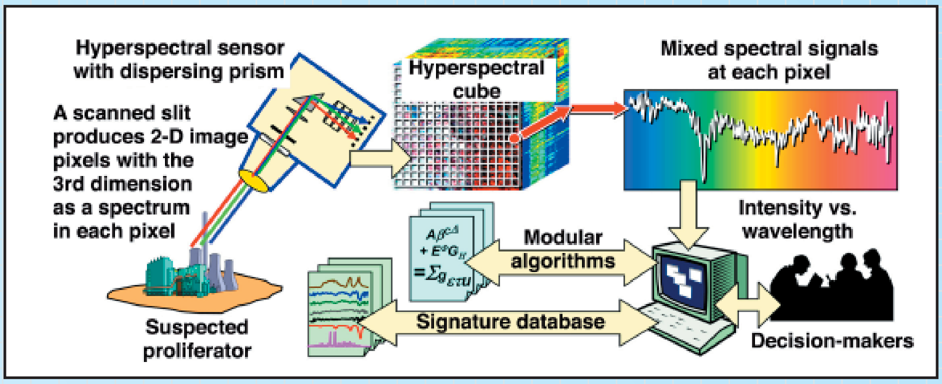
Research Highlight: Looking for Traces of Bomb-Making

Teams of DOE scientists and engineers around the country are creating and testing the hardware and software needed to detect and identify materials associated with the processes to make nuclear weapons. NA-22 funding since the early 1990s has provided long-term continuity for a new technology known as *hyperspectral imaging* (HSI). HSI is one avenue for detecting the proliferation of nuclear, chemical, and biological weapons, assessing bomb damage, and evaluating terrorist incidents and disasters.

HSI is an advanced form of spectroscopy, a branch of physics that studies the patterns of visible and non-visible light which many types of materials give off when illuminated by sunlight or some other light source. By closely measuring aspects of the reflected light, a material can be precisely identified. The HSI instrument, an advanced digital camera, operates remotely and can produce unique data based on measuring hundreds of light colors throughout a picture.

Multiple instruments used in concert may yield vast amounts of data for a given location, supplying unique information useful for policy-makers and defense decision-makers. Through the use of DOE-created libraries of weapon-related materials, combined with DOE-led advances in computation capabilities to process the huge quantities of information received, analysis of these data can quickly and accurately provide a near-real-time picture of potential illicit activities at sites where data are collected.



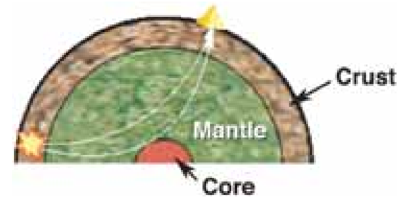
By emphasizing this new and highly promising technology, NA-22 continues it efforts to support the country's nonproliferation and homeland security needs.

Making Research Funds Pay Off for National Security: The Integration Process

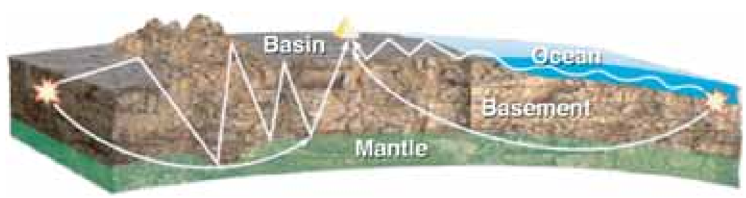
NA-22's Nuclear Explosion Monitoring Research and Engineering program (see the website at https://www.nemre.nnsa.doe.gov) provides research and engineering for the U.S. Atomic Energy Detection System (USAEDS) operated by the Air Force Technical Applications Center (AFTAC). As part of the ground-based systems part of the program, NA-22 integrates work by the national laboratories, universities, and industry into an operationally useful database known as the "National Nuclear Security Administration Knowledge Base." The USAEDS generates an extremely large quantity of data from detected seismic events and must quickly identify those requiring further action, depending on whether they are naturally seismic or the result of artificial explosions. To do this reliably, it is necessary to have an extensive background of geophysical phenomenology on hand. We need to understand, for example, the travel times of various seismic signals through different geological settings. The data collected must be made readily available for automated processing systems and further analysis by human experts. Having the Knowledge Base enables swift determinations to be made with a high degree of confidence.

The integration process begins after installation of a new seismic station. Collected data include seismic-signal travel times combined with amplitudes and other information useful for calibration. Seismic calibration consists of creating a model of seismic-wave propagation through the Earth's crust between a source and a station. It can take 3–5 *years* to collect and combine enough raw data from a seismic station before experts have a high degree of confidence about the locations of events. Whenever the true location or coordinates of disturbances become available, calibration information is updated to more accurately pinpoint events. Raw calibration data are packaged as research products and then further aggregated into Integrated Research Products and finally into Information Products. The validation, verification, and subsequent management of Information Products are critical to successful scientific integration. This also enables timely and reliable reporting by the United States National Data Center at AFTAC. The Knowledge Base results in high-quality support for monitoring treaties and nuclear testing moratoria. The full report, *The Integration Process for Incorporating Nuclear Explosion Monitoring Research Results into the National Nuclear Security Administration Knowledge Base* (SAND 2002-2772, November 2003), can be found on our website.

Teleseismic monitoring of large explosions previously could only detect events larger than 4 kilotons.



With regional wave-propagation factored in, smaller explosions of less than 4 kilotons are detected.



Seismic detection systems provide a primary means of effectively monitoring subsurface nuclear explosions. Nuclear tests at the Nevada Test Site have shown that without some prior knowledge of the propagation medium, the uncertainty in a yield estimate using these methods can be as high as a factor of ten. With some knowledge, the uncertainty can be cut to a factor of two; with very detailed knowledge, it can be cut even further. We are currently characterizing regional seismic properties. Regional seismic monitoring complements classical teleseismic monitoring to improve our understanding of the wave propagation of small explosions. Our comprehension of this will facilitate our efforts at bilateral and multilateral "Security Engagement" conducted by NA-242.

Satellite System Review Panel Meeting

In May, several NA-22 staff attended the semiannual Satellite System Review Panel (SSRP) meeting at AFTAC headquarters, Patrick Air Force Base in Florida. This panel reviews data from the United States Nuclear Detonation Detection System (USNDS).

The USNDS began in 1963 when predecessors to NA-22 in the Atomic Energy Commission were directed to design systems to fly aboard the Vela satellite. *Vela*, from the Spanish "to watch," was supposed to detect nuclear detonations within the Earth's atmosphere. The capability was improved over the years through advanced sensors hosted on the Defense Satellite Program (DSP) and Global Positioning System space vehicles. Several ground data-processing centers and mobile systems were also developed to process sensor data. Both ground- and space-based segments support treaty verification, strategic force management, and strike assessment missions for such users as Strategic Command, AFTAC, and the State Department.

The Office of Nonproliferation Research and Engineering has traditionally supplied space-qualified instruments and analytic support to USNDS via Los Alamos and Sandia National Laboratories. The SSRP reviews data from satellite systems we help develop. These systems discriminate the signal of a nuclear detonation from numerous sources of background noise. Lightning is a common source of terrestrial noise from electromagnetic pulse (EMP), but noise may also come from nearby sources like our sun or astrophysical disturbances in galaxies light years away.

Together with our national laboratories, NA-22 has designed dozens of payloads. Ten sensor systems fly aboard DSP satellites, the platform that succeeded Vela. Since 1971, this satellite has monitored ballistic missile launches and detected nuclear detonations from space using a number of x-ray, gamma ray, optical, and EMP sensors. The final launch of a DSP satellite is expected to take place late in 2005.

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